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A Knowledge-Based Approach to Crowd Classification

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Presentation Outline

- crowding phenomena
- general methodology
- tool development
- ontology implementation
- case study
- future works

Crowding phenomena

-The study of how people behave and move-

- Worldwide Research Network:
  - to describe human behaviors and interactions;
  - observations and data by multiple disciplines for heterogeneous aims using heterogeneous approaches:
    - Force-based models (Helbing, 1995);
    - Cellular Automata based models (Schadschneider, 2001);
    - Multi-Agent Systems based models (SCA, 2002);
    - …..

Crowding phenomena

-The study of how people behave and move-

- Worldwide Research Network:
  - to describe human behaviors and interactions;
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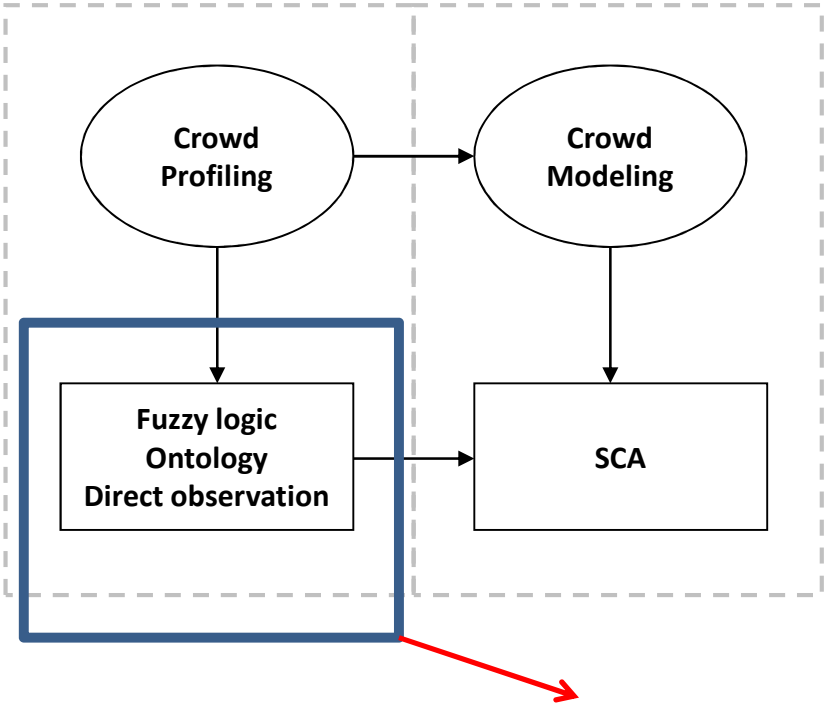
Loss of data, information and shared semantic

Initiatives oriented to data sharing for model benchmarking and validation in the Computer Science Area

The two-levels approach for crowd study

Crowd Profiling:
identify peculiar crowd features

Supported by:
Fuzzy logic
Ontology
Direct observation



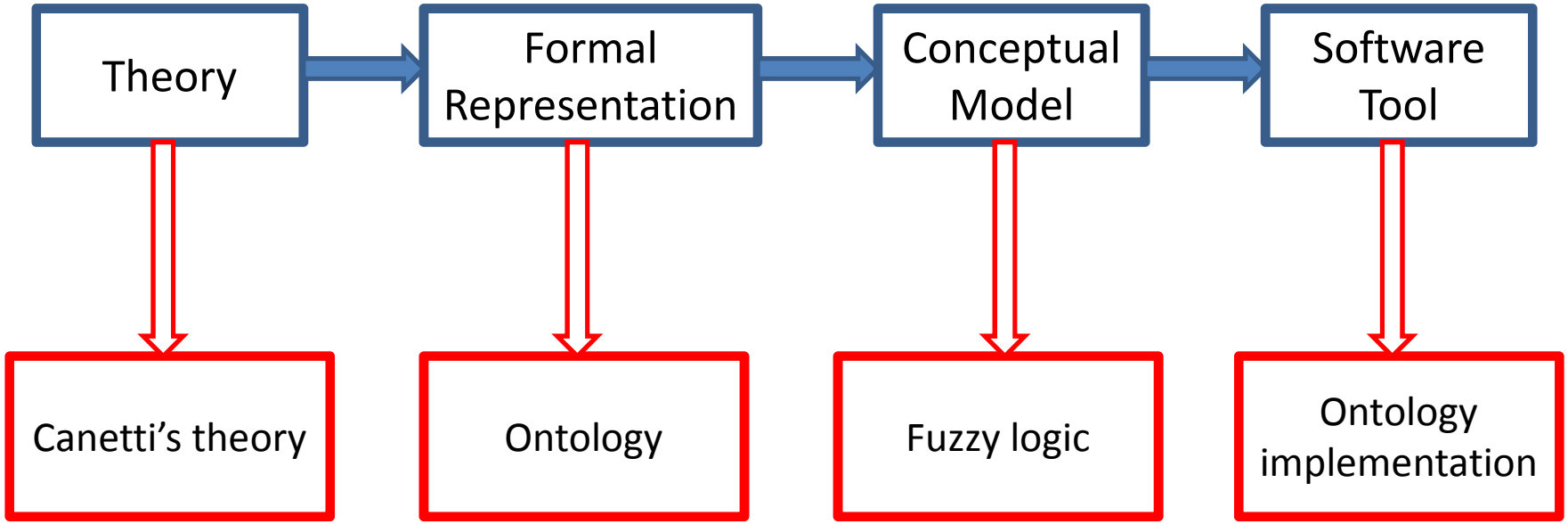
Crowd Modeling:
abstraction and representation of pedestrians behaviour

Supported by:
SCA

Tools for explicit representation of crowds domain which provides users with domain semantic to share knowledge.

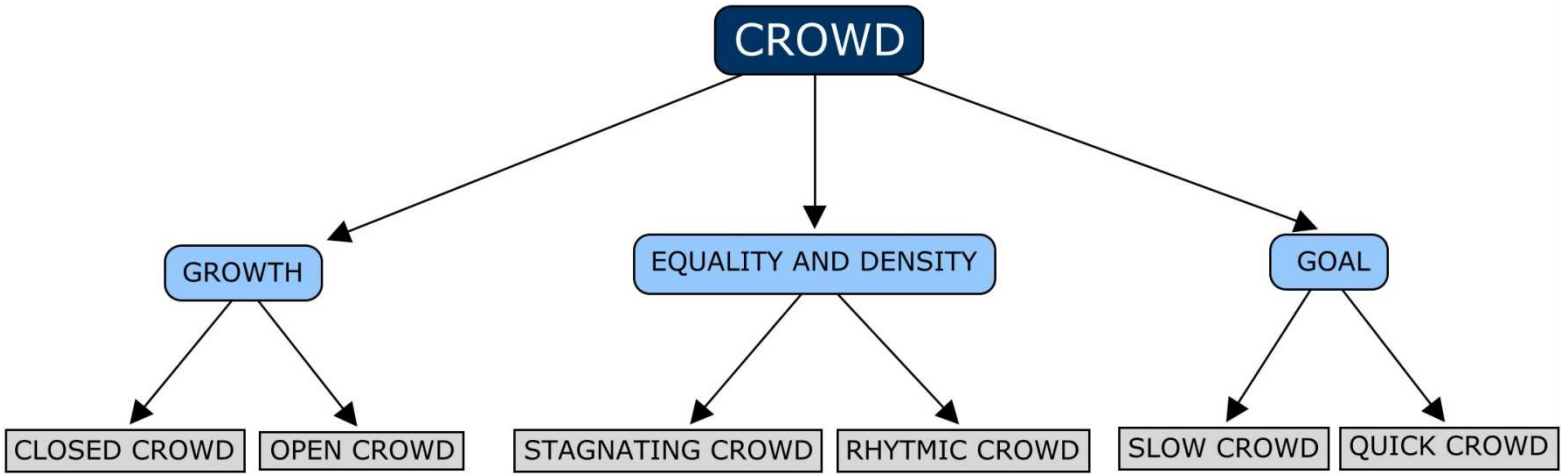
Tool development

- Methodology used for tool development:



First Step: Theory choice

- Elias Canetti “Crowds and Power”, 1960
  - empirical observations and studies on crowds’ phenomenology
- The analysis comprehends
  - considerations from many perspectives (psychological, anthropological, ideological, political…)
  - classification of crowds



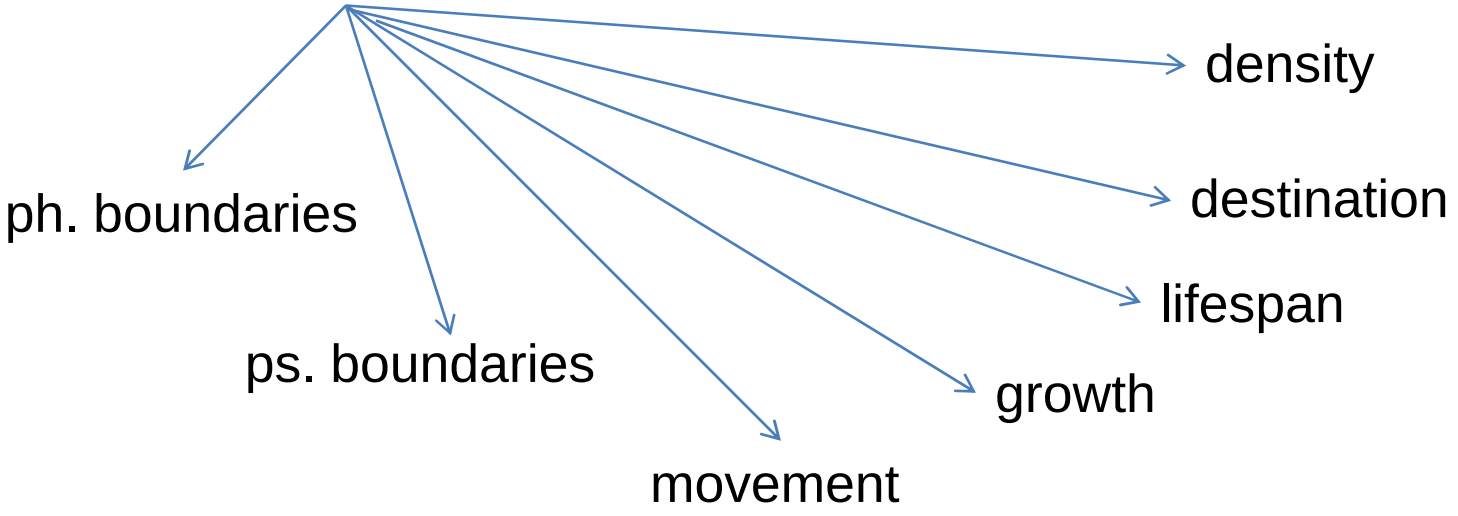
Second step:
formal representation of Canetti's theory

	Open	Closed	Stagnating	Rhythmic	Slow	Quick
Physical boundaries	No	Yes	-	-	-	-
Psychological boundaries	No	Yes	-	Yes	-	-
Movement	-	-	No	Yes	-	-
Density	-	-	High/ Medium	Low	High/ Medium	Low
Growth	High	Medium/ Low	-	Low	High	Medium/ Low
Lifespan	-	-	-	Medium/ Short	Long	Short
Destination	-	-	-	Near	Far	Near

Third Step:
identification of main concepts

Identification of main concepts:

- crowd → types of crowd
- features



How to model crowd features?

Third Step:
identification of main concepts

Features modeling:

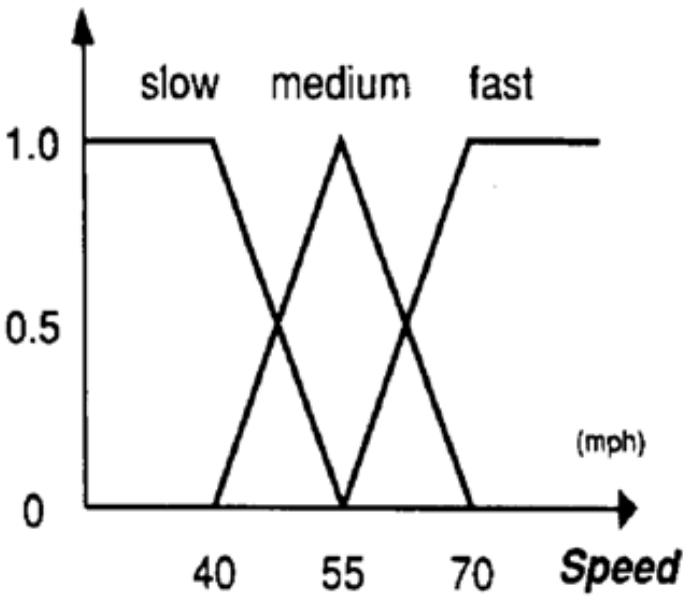
- crisp value: simple to evaluate, they can assume only boolean values
  - i.e. physical and psychological boundaries, movement
- linguistic quantifiers: high level of uncertainty, how to create relationships with observable values?
  - i.e. low, medium, high, …

Solution  **Fuzzy Logic**

Third Step:
identification of main concepts

Fuzzy Logic (Zadeh, 1996)

- a mathematical theory that simplifies the management of vague terms through the definition of fuzzy sets and Membership Functions
- Each fuzzy set is defined by a Membership Function that returns the membership degree in the interval [0..1] of a real value related to the fuzzy set



Third Step:
identification of main concepts

- Steps of fuzzy logic application:
  - Specification of fuzzy sets
    - e.g. subconcepts of high Density, high Growth, long Lifespan, near Destination
  - Creation of Membership Functions
    - Trapezoidal Functions for Density and Growth
    - Bell-shaped Functions for Lifespan and Destination

Third Step:
identification of main concepts

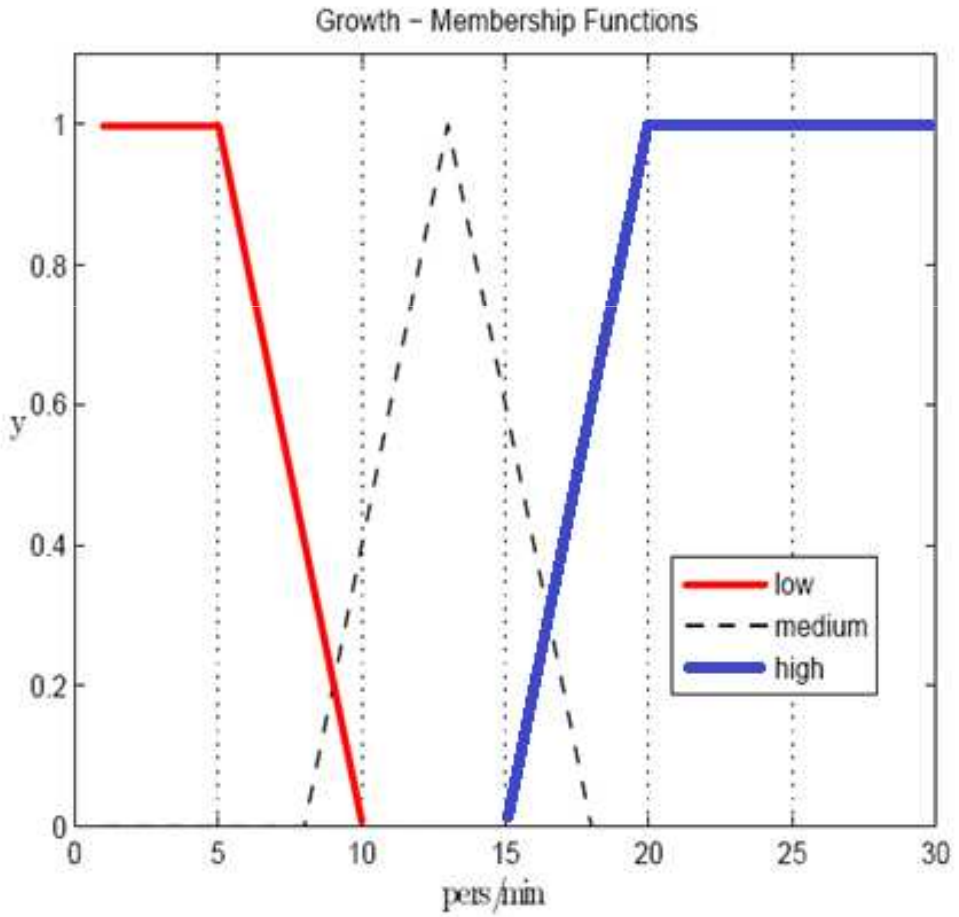
Trapezoidal Functions

- LowFunction(n, m) with $m > n$:

$$y = \begin{cases} 1 & \text{if} \quad 0 < x < n \\ \dfrac{m-x}{m-n} & \text{if} \quad n \leq x \leq m \\ 0 & \text{if} \quad x > m \end{cases}$$

- HighFunction (w, z) with $z > w$:

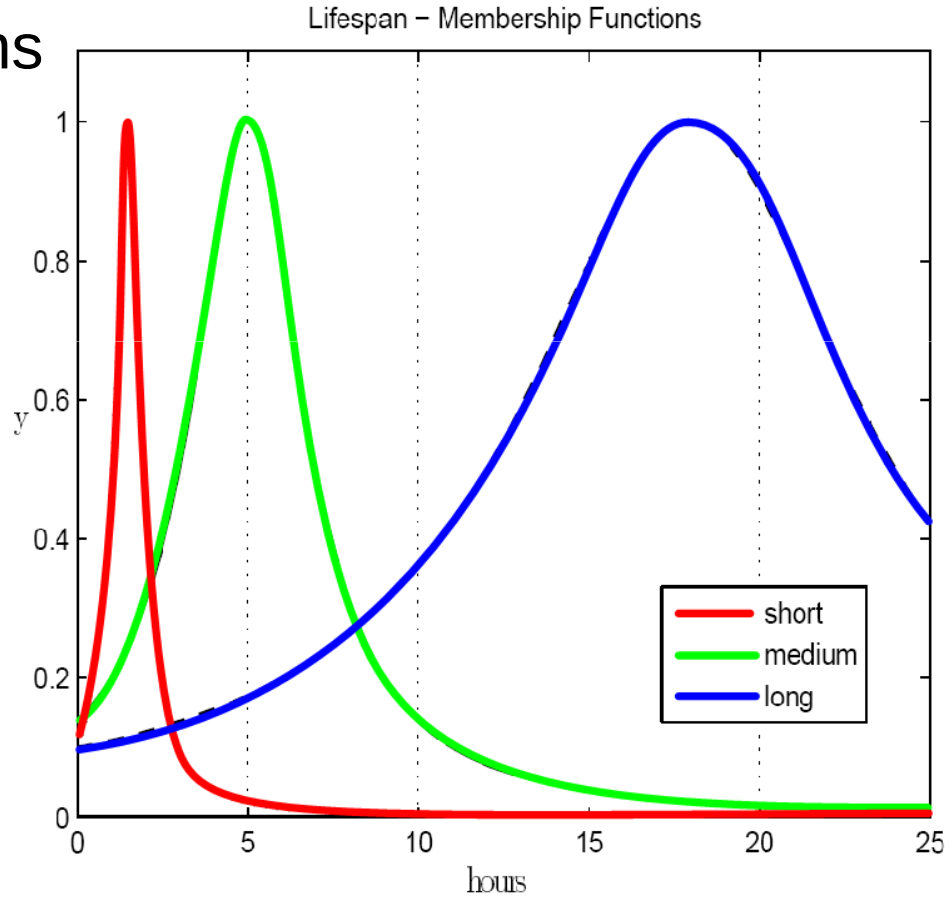
$$y = \begin{cases} 0 & \text{if} \quad x < w \\ \dfrac{x-w}{z-w} & \text{if} \quad w \leq x \leq z \\ 1 & \text{if} \quad x > z \end{cases}$$



Third Step:
identification of main concepts

Bell-shaped Functions

$$B(x, \gamma, \beta) = \frac{1}{1 + \left(\frac{x - \gamma}{\beta} \right)^2}$$

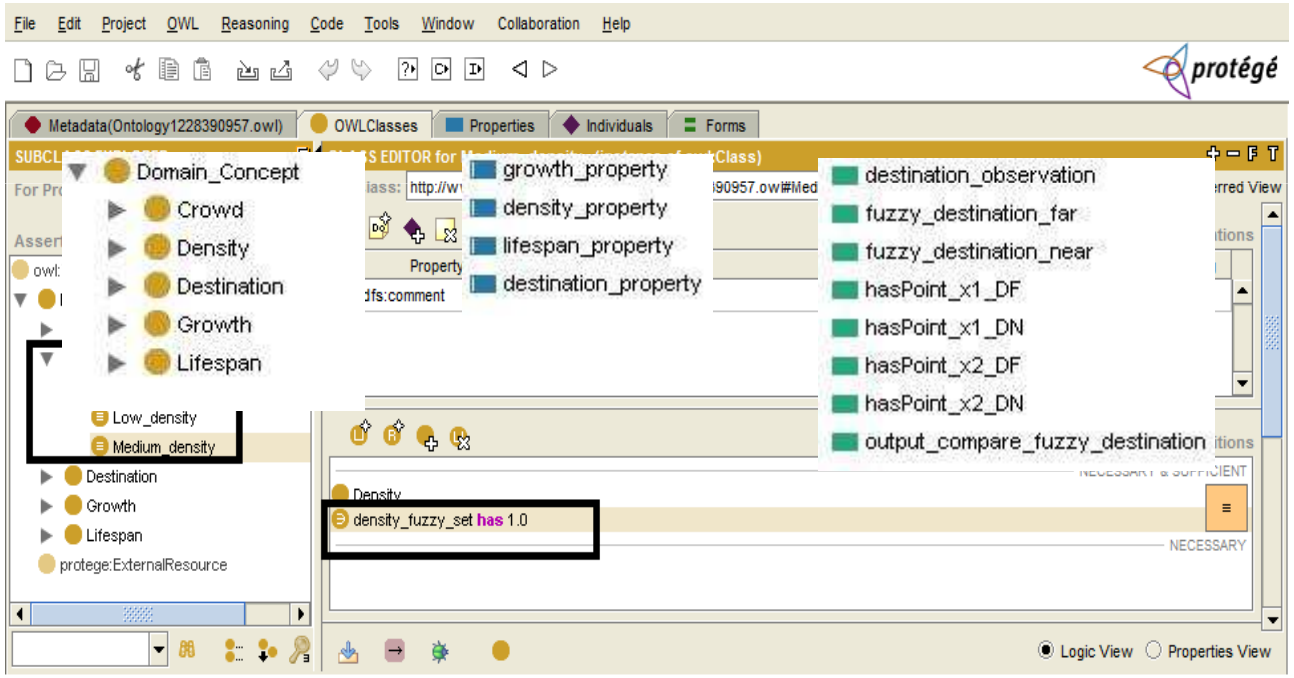


Membership Functions experimentally designed according to a given crowd scenario

Fourth Step:
ontology implementation

Implemented using protégé v. 3.3

– classes
– properties
– datatypes
– rules



Fourth Step:
ontology implementation

The ontology can be used following 3 steps:

- to collect data about density, growth, lifespan and destination and to verify the presence of movement, physical and psychological boundaries
- to put observations values (true, false or observable values) in the ontology (input step)
- to start the reasoners that produces crowd classification (output step)

Case Study:
concert crowd scenario

- study of different dynamics in the concert scenario
- collaborations with artists and music experts in order to collect experimental data by means of knowledge acquisition methodologies
- experimental data are related to:
  - Different kinds of music
  - Types of concerts
  - Types of singers/artists

to interpret crowd features in concert scenario and to establish Membership Functions parameters values

Case Study:
concert crowd scenario

Features interpretation:

- lifespan is described as the concert duration
- destination is described as songs average duration

Data sets create following the interpretation

	γ_{min}	γ_{medium}	γ_{max}	β_{min}	β_{medium}	β_{max}
Lifespan	1.5	5	18	0.5	2	6
Destination	4.3	-	2	2	-	50

Case Study:
a real case of concert scenario

SafariTour2008 - Lorenzo Jovanotti Cherubini and his band: Crowd profiling at closing-tour event of Safari tour 2008 (Palabrixia, Brescia, Italy, 13.12.2008)

Case Study:
a real case of concert scenario

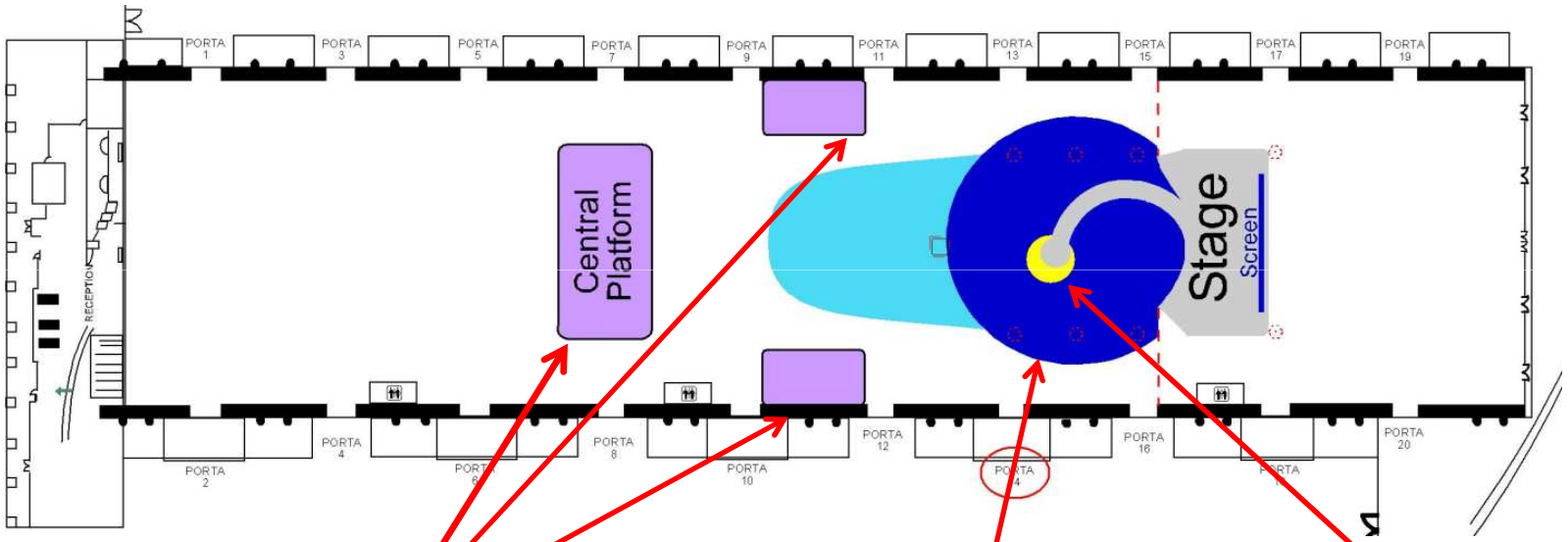
Analysis of the event :

	Analysis	Ontology Input
Physical boundaries	Structure	Yes
Psychological boundaries	Pay ticket	Yes
Movement	Not uniform	-
Density	People / Area	2 per/mq
Growth	Affluence / Gates	14 pers/min
Lifespan	Concert duration	2:00 hours
Destination	Lifespan / Songs number	4:24 min

Ontological Representation

Case Study:
a real case of concert scenario

Crowd Classification: Closed and Quick Crowd



Platform Audience: closed and quick crowd without movement

Stalls Audience: closed and quick crowd with movement

Fan Club: closed and slow crowd

Future Works

- ongoing research project aiming at the development of decision support crowd management
- analysis of different crowd scenarios in order to establish other Membership Functions parameters (e.g. sports events)
- ontology testing in concert scenario using data collected during tours and concerts
- update ontology for 

v.4 using a plugin developed for fuzzy values calculation

Some references..

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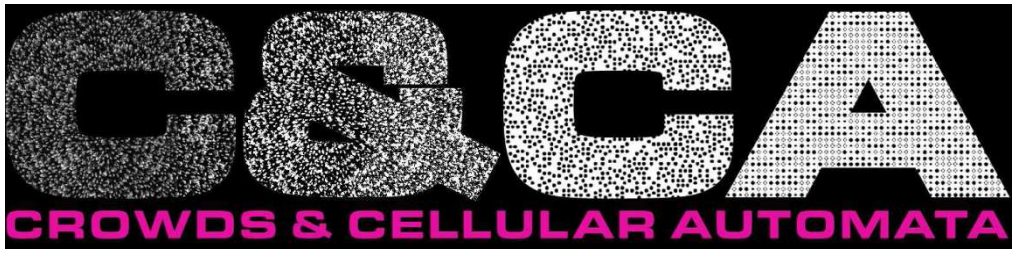

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CROWDS & CELLULAR AUTOMATA

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Thank you!

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